EMERGENCE AND SUBMERGENCE OF LAND.

AT the recent anniversary of the Geological Society, when the president was unable from illness to be present, his place was taken by Sir Archibald Geikie, who prepared an address for the occasion on the evidence supplied by the British Isles as to the problem of the causes of changes in the relative levels of sea and land. This address appears in full in the *Quarterly Journal* of the society, and we here reproduce it in abstract.

(i.) *Emergence.*—Geologists in the British Isles have long indulged the confident belief that Raised Beaches afford demonstrative proof of changes in the relative levels of sea and land. The abundant and striking examples of them around our coasts have been universally accepted among us as marking former sea-margins, whether the sea be supposed to have risen upon the land or the land to have been upheaved above the sea. The recurrence of precisely similar terraces along the western coast of Norway, but on a still more impressive scale, has been regarded as furnishing evidence of an extensive emergence of land, from the south of Britain to the northern end of the Scandinavian peninsula. Prof. Suess, however, seeks to show that, at least as regards the north-western coast of Norway, these opinions are based upon a misreading of the evidence. After his visit to that region, and his study of the literature of the strand-lines, there so wonderfully developed, he has come to the conclusion that the Norwegian fjords furnish no argument against his doctrine that there has been no recent upheaval of the land. He asserts that "we must interpret all the *seter* [rock-shelves] and the great majority of the terraces in the fjords of Western Norway as proofs of the retreat of the ice that once covered so much of the peninsula, and not as proofs of any oscillations of the surface of the sea, still less of any movement of the solid land." It would widen the inquiry too much to enter upon an examination of the evidence as it is presented in Scandinavia. But the author of the address, having been all his life familiar with the strand-lines of this country, and having traced those of the Norwegian coast from Bergen to Hammerfest, directed attention to one or two of the insuperable difficulties with which Prof. Suess's theoretical explanation seemed to him to be beset. The great Austrian geologist appears to have unwittingly confounded two sets of beach-lines, which differ a good deal from each other in general character, and are entirely distinct in origin. Availing himself of the remarkably full and interesting researches of Scandinavian geologists regarding the glaciation of their country, he dwells upon the importance of the terraces left by the fresh-water lakes that were dammed back by the great ice-sheet as it retired. He believes that these phenomena extended even to the Norwegian coast, and that the strand-lines of the fjords, whether in the form of platforms eroded out of the solid rock (seter) or terraces of sediment, mark former levels of lakes that filled these valleys when their mouths were blocked up with the ice-sheet. As the lowest of these strand-lines includes sands and gravels crowded with marine shells, he is compelled to admit that it marks a former sea-beach. But he endeavours to discriminate between it and the other horizontal shelves, which follow it in parallel lines at higher levels. He affirms that the latter present a series of "characters absolutely irreconcilable with what we know of the action of the sea along a shore"—such as the series of fragmentary terraces found at increasing heights inland, their absence from the parts near the general coast-line, and the breadth of the seter. He passes lightly over the fact that some of these higher terraces have yielded marine organisms which are progressively of more Arctic character, according to their altitude, and according, consequently, to the antiquity of the sediments in which they lie.

Now, according to the experience of those northern geologists who have specially studied Scandinavian glaciation, the lakes that were formed by the ponding-back of the drainage against the flanks of the ice-sheet lie to the east of the watershed of the peninsula. These observers have ascertained that when this ice-sheet was waning, it retreated eastward from the backbone of the country and lay on the eastern or Swedish slope, leaving a gradually increasing breadth of ground clear of ice. The streams flowing eastward over this liberated area had their drainage arrested against the margin of the ice; and hence arose a vast series of lakes which lasted for longer or shorter periods, until, by the continued creeping backward of the ice, their contents were drained off to lower levels. A multitude of records of old water-levels, or "strand-lines," was thus left over the surface of the country. It is the opinion of Scandinavian geologists that all the terraces not of marine origin lie within that area.

As one of the distinctive characters of the shore-lines left by the glacier-lakes, the author of the "Antlitz der Erde" cites the occurrence of the rock-shelves or platforms (seter) eroded out of the solid rock, and he refers the origin of these common features of the fjords to the daily oscillations of temperature at the surface of the lakes. A reference to the abundant examples of such rock-shelves in our own islands showed that this explanation is at least inadequate. If, however, for a moment, we grant that the strand-lines, including the seter of the Norwegian fjords, do mark levels of former fresh-water lakes, it is obvious that, in order to pond the drainage back and produce these lakes, the mouths of the fjords must have been in some way blocked up by a barrier which has disappeared. If this barrier were land-ice, as Prof. Suess appears to assume, the water would rise behind it, until, if the overflow found no escape into the Atlantic, it would pass over the watershed, and joining the various bodies of water that were there intercepted by the great Swedish ice-sheet, would eventually find its way into the Gulf of Bothnia. There would thus be two huge bodies of ice, between which the drainage was accumulated. We must remember, however, that the strand-lines are not confined to the fjords, but sweep round the coast on either side, and even appear on the islands that flank the mainland of Norway, some of them actually looking out to the open sea. The supposed ice-sheet must therefore have lain mainly outside these islands. But there is absolutely no evidence of any such detached western ice-body, and every reason to believe that it never existed.

At the period of maximum glaciation the ice-sheet probably advanced westward beyond the present limits of the land. But, when it began to retreat, it would naturally creep backward up the fjords, which would be still the main lines of ice-drainage. We can conceive, indeed, that at an early stage of this retreat, a glacier or ice-lobe may here and there have blocked up a large valley and produced a lake, as in the instances cited by Prof. Suess from Greenland. But the strand-lines of western Norway are not exceptional phenomena. They continue as characteristic features of the coast-line and of the fjords for several hundred miles, and must owe their origin to some general and widely extending cause. That they are true sea-beaches, as has been generally believed, Sir Archibald Geikie had not the smallest doubt.

Fortunately, we possess in our own islands a body of evidence bearing on this question, not certainly as voluminous and impressive as that of Scandinavia, but having the compensating advantage of great simplicity and clearness. On the one hand, the famous Parallel Roads of Glen Spean and Glen Roy, and those of other less known valleys, stand out as acknowledged relics of glacier-lakes; while round our coasts, on both sides of the country, raised beaches, which have been hitherto regarded as old sea-margins, run for hundreds of miles. These two series of terraces are found close together, yet there is no difficulty in drawing a satisfactory distinction between them. Indeed, their proximity enables us all the more clearly to perceive their contrasts.

There must, of course, be certain general resemblances between the littoral formations of lakes and of the sea. The erosion produced by the waves or wavelets of a body of fresh water is similar in kind to that performed by the sea, although different in degree. In like manner, the beaches of deposit formed in lakes possess, on a minor scale, many of the characters of those accumulated along the sea-shore. And it may readily be granted that, in isolated exposures of some old beach, it may be difficult or impossible to decide, in default of evidence from elsewhere, whether the phenomena observable are to be assigned to the work of the sea or of a lake. Nevertheless, on a review of the whole evidence, at least as it is presented in this country, Sir Archibald felt very confident that there is no risk of confusion in this matter. The marine terraces maintain their distinctive features up to the very foot of the slopes where the lake terraces begin, while those in turn are marked by other special peculiarities.

Let any observer who has followed the great 50-foot raised beach along the western coast of Scotland and up the Linnhe Loch to the mouth of the Great Glen, look away to the right hand where the wide Strath of Spean leads into the interior. While yet standing on the platform of the raised beach, if the air be clear, his eye may detect the beginning of a line, drawn as with a ruler, at the same height along the slopes on either side of the valley. This is the lowest of the three great Parallel Roads of Glen Roy, and runs at a height of 850 feet above the level of the sea. If he will now ascend into Glen Roy, where the three terraces are best seen, he will soon be struck by the distinctive differences between these old lake-margins and the raised beaches with which he has already made himself familiar. In the first place, he will remark their faintness as compared with the marine platforms of the coast. Though readily traceable from a distance in their horizontal continuity, they are in many places hardly discernible when one is actually standing upon them. A little examination soon reveals that each of them has been produced mainly by the arrest of sediment washed from the slopes above into the water of the vanished lake. Instructive illustrations of this process may often be observed along the sides of reservoirs which have been constructed in steep-sided valleys: there each prolonged halt of the water at a particular level is marked by a shelf of detritus which, blown in by wind and washed down the declivities by rain, is stopped when it enters the water, where it accumulates as a miniature beach.

Here and there, especially on more exposed projections of the hillsides, there has been a little cutting-back by the shore-waves or drifting ice-floes of the old lake in Glen Roy. Occasionally also, where a streamlet has entered the water, its arrested detritus has accumulated as a broad, flat delta or terrace. But it is manifest that, in such limited expanses of water, wind-waves could have had comparatively little erosive power. Nor can we imagine that, even if the water froze, its floe-ice could have had any potent influence in sawing into the rocks of the declivities, and producing seter or rock-shelves. Certainly throughout this wonderful assemblage of lake-shores, there is nothing for a moment to be compared to the incised platforms of rock so abundant as part of the raised beaches of the western coast of Scotland. We must remember also that the production of such ice-dammed lakes took place as a mere episode in the retreat of the ice. No means are available to determine what may have been the length of time during which the water stood at the level of any one of these Parallel Roads. We may probably infer, from the absence of well marked and continuous intervening shore-lines, that the shrinkage of the ice and the consequent lowering of the level of the water were somewhat rapid.

The Parallel Roads of Lochaber, although the most imposing, are not the only examples of the shore-lines of ancient glacier-lakes in this country. Another striking case is that of Strath Bran in Ross-shire, where the glaciers descending from the mountains on each side ponded back the drainage of the valley, and sent it across the present watershed of the country at a height of about 600 feet above the sea. The conspicuous gravel-terraces at Achnashean are a memorial of this vanished sheet of water.

Now, with these undoubted records of ancient lakes, let us compare the structure and distribution of our Raised Beaches. These shore-lines are found, on both sides of Scotland, at approximately the same heights above the level of the sea. They are partly terraces of deposit, and partly true seter or platforms cut out of the solid rock, the same beach presenting frequent alternations of both structures. In general, it may be said that the detrital terraces are found chiefly in bays, sea-lochs, or other sheltered places, while the rock-terraces are conspicuous in more open sounds and exposed parts of the coast, where the tidal currents and wind-waves are most powerful.

As the highest terraces are the oldest, they have been longest exposed to the influences of denudation, and are thus the faintest and most fragmentary. But the dimensions and perfection of a raised beach do not depend merely on age, but in large measure on the length of time that the water stood at that level, and the varying local conditions that favoured or retarded the planing-down of solid rock or the deposition of littoral sediment.

That these beaches unquestionably mark shore-lines of the sea may be inferred on three grounds:—(1) Their position on both sides of the island at corresponding heights. No possible arrangement of ice-dams in the Atlantic and in the basin of the North Sea can be conceived that would have everywhere ponded back the land-drainage to similar levels. (2) Their independence of local conditions. The same terrace may be traced down both sides of a sea-loch and round the coast into the next loch, retaining all the while its horizontal continuity. Not only on the mainland, but on the chain of islands outside, the same parallel bar has been incised, both on the inner or sheltered side and also on the outer flank looking to the open Atlantic. (3) Their organic remains. From the youngest of the beaches up to the highest, the terraces of deposit contain marine organisms which have not been scooped out of some earlier formation, but lie in the positions in which the animals died, or into which they were washed by shore-waves and currents. The fossils of the latest beaches are entirely identical, or almost so, with forms still living in the adjacent seas, while those of the higher beaches are boreal or Arctic.

In some sheltered places, such as the Dornoch Firth, especially near Tain, and some inlets on the west side of the island of Jura, a number of successive bars or terraces of deposit may be observed up to heights of 100 feet or more above the sea. But there are in Scotland three strand-lines so conspicuous and so persistent that attention may be confined to them. From what has been taken to be their average height above mean sea-level or Ordnance-datum, they are known respectively as the 100-foot, the 50-foot, and the 25-foot beaches.

The author here adverted to what he had long regarded as a reproach to the geologists of this country. No systematic effort has ever yet been made to determine accurately, by a series of careful levellings, the precise heights of these old shore-lines. We only know that, roughly speaking, a raised beach retains its level for long distances, and appears to lie at the same height on both sides of the country. But we are still ignorant whether or not an appreciable difference of level might not be detected between the western and the eastern development of the same beach, nor do we know whether it would not betray some variation in its height between its northern and southern limits. There seems to be a tendency for the levels of the beaches to rise slightly towards the head of an estuary or sea-loch. But whether this difference is more than can be accounted for by the ordinary elevation of the tidal wave as it ascends a narrowing inlet remains to be determined.

Obviously, until accurate information is obtained on all ascertainable differences of level in the system of our raised beaches, we must remain unprovided with some of the most important material for a discussion of the history of these beaches. It is surely not too much to hope that one or more observers, endowed with the requisite geological knowledge and geodetic skill, may before long be found who will undertake the investigation of this interesting subject, and thus aid in the solution of a problem which does not merely concern the evolution of our own islands, but is of high importance as a question in geological theory.

The 100-foot, 50-foot and 25-foot beaches of Scotland were briefly described, and it was pointed out that in the structure of these old sea-margins a feature of special interest is presented by the platforms which have been eroded out of the solid rock, and which afford not a little light as to the origin of the Norwegian seter. The surface of these rock-terraces is flat, and usually covered with a thin coating of grass-grown soil through which harder knobs and stacks of the underlying rock here and there protrude. At the inner margin of the terrace, the rocks rise into a cliff or steep bank, the base of which is frequently pierced with caves. That these caves were mainly due to erosion by moving water is abundantly evident in the rounded and smoothed surfaces of their sides. Their floors are often rough with round shingle, which has undoubtedly been the material employed by nature in their excavation. No one who has made himself familiar with the rock-platforms which at the present day are in course of erosion by the sea along these same coasts can for a moment doubt that the rock-platforms of the raised beaches which, down to the minutest point, resemble them, have likewise been eroded by the waves of the sea.

That the daily oscillations of temperature invoked by Prof. Suess in explanation of the Norwegian seter have had their share in the erosion of these Scottish examples cannot be doubted. But this share is evidently feeble in amount now, although it may have been more considerable during the Glacial period. More potent as a contributory influence in the erosion of the older terraces was probably the action of floating ice, driven along the shores by winds and tidal currents. Down to the time of the 50-foot beach, when glaciers in the north of Scotland descended to the edge of the sea, there may have been a good deal of such ice in the more enclosed sea-lochs, where the water, freshened by the discharge of melting snow-fields and glaciers, might itself be covered with a cake of ice. And there was not improbably a good deal more ice in the fjords of Norway. The grinding and rasping action of such ice, driven by gales ashore, has long been remarked. But in any case we are justified in regarding the Scottish seter as examples of truly marine erosion, and there appears to be no reason why those of Norway should not have had the same origin. It is at least clear that the statement that the characters of seter " are absolutely irreconcilable with what we know of the action of the sea near its surface," cannot be sustained.

Certain features of the extension of the raised beaches throughout Britain appear to be of fundamental importance in relation to the discussion of the problem of the emergence of land. Though so persistent along both the western and eastern coasts of Scotland, these beaches, as is now well known, do not stretch northward into the Orkney and Shetland Isles. Along precipitous sea-fronts we could not expect to meet with them, but among these islands there are endless sheltered inlets and bays which, had they indented the shores of the mainland of Scotland, would undoubtedly have had their fringe of terraces. The conditions for the development and preservation of the beaches were so entirely favourable, that their absence can only be legitimately accounted for on the supposition that they can never have existed here. Still farther north, among the Færöe Isles, no trace of any raised beaches has been found among the numerous natural harbours and creeks that break the monotony of the vast ranges of basalt-precipice. Here, again, we cannot suppose that any such beaches were ever formed.

In the southward extension of the Scottish raised beaches these features begin to lose their distinctness as they are traced into England. The 100-foot beach, which has not been recognised along the northern coast of Sutherland or in Caithness, appears also to fail before it reaches the English coast. It is well marked in the estuaries of the Clyde and Forth, whence in a fragmentary condition it has been traced into Wigtonshire on the one side and to the north of Berwickshire on the other. But no remnants of it appear to have been detected in the North of England.

The raised beaches of the north and east of England were briefly referred to, and it was then shown that in England and Wales the most continuous and best preserved examples are to be seen on the coasts of the southern counties. The lower raised beaches along the coasts of Dorset, Devon and Cornwall have long been known, although their geological age, their history, and their relation to the later phases of Pleistocene time, have not yet been satisfactorily cleared up. William Pengelly, who devoted so much time to this subject, clearly proved that these beaches do not stand now at their original level, but that after their formation the region was upraised to the amount, as estimated by him, of not less than 70 feet, when the lowest sunk forests flourished as land-surfaces, and that thereafter came a submergence of certainly 40 and perhaps many more feet.

Mr. Tiddeman has shown that, in Gower, on the coast of Glamorgan, a raised beach which lies from 10 to 30 feet above the level of the modern beach, and contains littoral shells of common species, is yet older than at least some part of the Glacial period, for it is overlain by Glacial drift. In this case, also, its present is probably not its original level. There is evidence of considerable submergence, at a comparatively late period, farther east in the same county and along the southern coast of England, and the inter-Glacial or pre-Glacial raised beaches of the whole of this region doubtless stood at one time higher above the sea-level than they do now.

The raised beaches of Ireland were alluded to, special attention being directed to an ancient shore-line at Cork Harbour, which has recently been traced by Messrs. Muff and Wright, of the Geological Survey, not only within the harbour, but for a long distance on the shore to the east and west of that inlet. Though only a few feet above the present high-water mark, this beach has been ascertained to be older than the oldest Irish Boulder-clay, for it is overlain by the so-called " shelly marl " which was brought in upon the land from the sea-basin. The similarity of position and antiquity between this beach and that underlying the drift in Gower is obviously as important as it is interesting. A shore-line, which must be of pre-Glacial or inter-Glacial age, is traceable in the south of Ireland and in South Wales. It has not only survived the erosive processes of the Glacial period, but it appears to have outlived some serious alterations in the relative levels of sea and land, which have taken place since its formation. Moreover, we have to note the fact that neither at Cork nor in Gower does any younger post-Glacial terrace appear to be recognisable. If we might judge from the analogy of other parts of these islands where the succession of raised beaches is tolerably complete, we should infer that if ever any later terrace existed here it must now be submerged—an inference which, it will be observed, is supported by the evidence of considerable submergence in South Wales and on the southern coast of Hampshire.

(ii.) *Submergence.*—Of the various kinds of proof of the submersion of terrestrial surfaces furnished in these islands only two were dealt with : first, the extension of land-valleys beneath the sea, and, secondly, the existence of what are known as sunk forests.

(1) That the fjords of Norway, the sea-lochs of the west of Scotland, and the harbours or inlets of the west of Ireland were originally valleys on the dry land, although now deeply submerged, has long been an accepted belief among those geologists who have specially considered the subject. The interval of time which has elapsed since this submergence has not sufficed to fill up with sediment these submarine depressions. By a study of the sea-charts, we can still trace the winding curves of the ancient valleys, and can even here and there detect among them the basins which, when the present sea-bottom was a land-surface, were filled with fresh-water lakes. On the sea-floor to the east of our own country and of Scandinavia, such relics of subaërial denudation are less imposingly preserved, yet evidence of the submergence of land-valleys has been noted there also. It must of course be remembered that the land on that side is of much lower altitude than on the western coasts, that the ground slopes gently under the sea, and that the valleys are comparatively insignificant depressions on its general surface. Moreover, the more abundant drainage on the longer slope east of the watershed, and the much greater development of drift on that side, leads to a far more copious discharge of sediment into the shallow North Sea and the Gulf of Bothnia, and the submarine prolongations of the old land-valleys are thus apt to be buried under recent accumulations of detritus. There may, however, perhaps be another cause for the contrast between the profoundly indented and precipitous western coast and the comparatively low and monotonous trend of the eastern coast. The author had long been disposed to believe that the submergence has been greater towards the west than towards the east. In the prolongation of the West Highland sea-lochs on the floor of the Atlantic outside, the original land-surface sometimes lies 600 feet or more below the present sea-level. If the submerged land-surface of north-western Europe could be upraised some 600 feet, the submarine prolongations of the sea-lochs would once more become glens and straths, and their rock-basins would again be turned into fresh-water lakes.

There is no similar series of well marked submerged valleys on the floor of the North Sea from which to estimate the amount of submergence of that tract, at least half of which, at no very distant date, formed a land-surface that connected Britain with the rest of the Continent. The charts show this sea-floor to consist of two distinct portions. The northern half forms a plain, which appears to slope gradually towards the north. The southern half, however, rises somewhat rapidly from the edge of that plain into an escarpment that runs in a north-easterly direction for a distance of 500 miles, from off Flamborough Head to the Skagerrak. From the top of this escarpment the surface undulates southward as a higher submarine plain, traversed by the still feebly traceable submerged valleys of the Elbe, the Rhine, and the Thames, and covering an area of more than 50,000 square miles. An uprise of not more than 300 feet would turn this tract into a rolling plateau of dry land, like the downs and wolds of Yorkshire, which are its emerged continuation. Such an amount of uplift would probably be amply sufficient for the transaction of all the later geological history of the region. The conversion of the area into a sea-bottom may not have been a continuous process. It was probably in operation during the early stages of the Glacial period, and its latest phases come down at least into Neolithic time.

(2) The sheets of peat with stools and trunks of trees, known as sunk or submerged forests, and of such frequent occurrence around the coasts of the British Isles, have long been confidently regarded as proofs of recent subsidence of the land. That they generally mark former land-surfaces cannot be doubted, for the tree stumps are seen to send their roots down into the soil underneath, and manifestly stand in the places where they originally grew. The presence of hazel-nuts, elytra of beetles, land-snails, and other terrestrial organisms, affords further confirmation of this conclusion. The great majority of these vegetable accumulations are found between tide-marks in bays and estuaries, and in many cases they can be seen to pass below the limits of the lowest tides, and thus to be constantly in part submerged. The trees and the fresh-water plants must have lived above the reach of the sea, so that they now lie 20 feet or more below the level at which they originally grew, and the conclusion has been drawn that they mark a general subsidence of these islands, to the amount of at least 20 feet, at a comparatively recent date.

Sir Archibald Geikie was inclined to believe that this conclusion has been rather too sweepingly drawn. That some of the submerged forests may be satisfactorily accounted for without any change in the level of the land or of the sea was urgently enforced more than eighty years ago by John Fleming, in reference to the examples first brought to notice by him in the estuaries of the Tay and the Forth. It will be readily understood that, in the later stages of the Glacial period, when much detritus was swept off the land into the sea, the conditions would probably be especially favourable for the formation of alluvial bars along our coasts, such as are now in course of accumulation for hundreds of miles on the southern coast of Iceland, where some of the features of that period may still be said to linger. Behind these barriers lagoons would arise, which in course of time might become marshes, and eventually peaty flats, supporting a growth of trees. But when the supply of sediment failed, and the sea, instead of heaping up the bars, began to breach them, the level of the bogs would sink by the escape of their water to the beach, and the tide at high-water would overflow and kill off the forests. Occasionally, owing to the action of underground drainage, the seaward margins of forest-covered peaty flats may have been detached from the main body and launched downward on the beach, even beneath low-water mark.

Had our littoral sunk forests been confined to a few places where the topographical conditions were specially favourable for their production, we may concede that they would not in themselves furnish sufficient proof of a shift of level, either on the part of the land or of the sea. But when we consider their widespread distribution all round the margin of these islands, even on those shores where it is difficult to believe that there has been any subsidence or slipping downward of a land-surface owing to the draining off of underground water, we may well doubt whether the old belief should be disturbed, that the facts, taken as a whole, prove a general submergence.

Fortunately, the evidence available on this subject allows us to go a step farther. We need not be content with such debateable proofs as are furnished by the sunk forests between tide-marks, for land-surfaces can be adduced which are buried beneath marine accumulations in circumstances that leave no doubt as to the facts of submergence.

The author, after presenting some details proving submergence at Belfast, at Hull, and at Grimsby, to the extent of sometimes as much as 52 feet, stated that on the coast of South Wales interesting sections had been laid open in the excavation for the Barry Docks, in Glamorgan, furnishing conclusive proof of a succession of at least four layers of peat overlain by estuarine deposits, and in a situation which precludes any recourse to local settlement by drainage of underground water or downward slipping. The strata are manifestly undisturbed, and the lowest is an unmistakable land-surface. It consists of peat full of remains of oak, hazel, cornel, hawthorn, and willow, together with crushed shells of Hyalinia and, apparently, Pisidium and Planorbis. The soil underneath this forest-growth has yielded specimens of Helix, Hyalinia, Succinea, Limnæa, Pupa, and Valvata. This buried forest-growth lies at a depth of 35 feet beneath Ordnance-datum, or 55 feet beneath the line of high-water of ordinary spring tides. It proves a submergence of at least 55 feet, and the peat-bands at higher levels mark successive pauses in this submergence. That the movement was in progress in Neolithic time may be concluded from the occurrence of a portion of a polished celt in the uppermost layer of peat, from which also two bone needles are reported to have been obtained. Mr. Strahan informed the author that, wherever excavations have been made at the mouths of the valleys on the coast of South Wales, similar layers of peat have been cut through at depths below low-water mark. It would thus appear that the submergence has been general all along the coast-line.

On the southern English coast similar evidence of a considerable change of level has long been known. During the extensive excavations for new dock accommodation at Southampton, a bed of peat, 10 feet thick, has been found, descending to a depth of 43 feet below Ordnance-datum. This vegetable accumulation has yielded many land and fresh-water shells; abundant trunks of oak with roots, sometimes 2 feet long, passing down into the loam beneath; plentiful remains of beech and hazel, together with some birch and pine. The plants also include bulrush, sedge, bog-myrtle, heaths, and bracken. From this bed, bones, horn-cores, and part of the skull of *Bos primigenius* were obtained; likewise horns and bones of red deer, tusk of boar, bones of hare, and horn of reindeer. Traces of man were found in the same deposit, as shown by the occurrence of dark flint-flakes, a round perforated hammer-stone, and a fine bone needle polished by use.

There is thus evidence of a comparatively recent submergence of the south-west of England to the extent of at least 50 or 60 feet. We are probably justified in considering the present position of the Glacial raised beach in Gower as a further indication of the same movement, and there seems no reason why we should not connect the evidence of this beach with that of the terrace lately detected in Cork. If these tracts are included in our survey, we see that the submergence probably stretched across South Wales and St. George's Channel to the south of Ireland. The evidence from Hull and Grimsby, which shows that a similar marked submergence has taken place along part of the east coast, not improbably indicates that the change of level extended across Wales and the centre of England. This submergence appears to be the latest in the long series of oscillations which have affected the southern portions of our islands. No proof has yet been obtained that so serious an amount of recent submergence has extended farther north. In the northern tracts the latest recorded change of level has been an emergence of the land in Neolithic time.

(iii.) *Bearing of the Evidence on the Causes of Emergence and Submergence.*—In conclusion, the author pointed out the inferences that appeared to him to be deducible from the evidence obtainable in the British Isles, in regard to the causes which, in this region, have determined the emergence and submergence of land. The vertical range of the changes of level to which the discussion in this address was limited amounts at least to as much as 700 feet, that is, some 600 feet below and 100 feet above the surface of the sea. But it will be remembered that, if we include all the deposits that contain recent marine shells *in situ,* the range of movement will be found considerably to exceed 1000 feet. The problem to be solved is whether this wide amplitude of shift in the relative levels of sea and land should be attributed to variations in the height of the surface of the oceanic envelope, or to secular movements of the terrestrial crust.

Any change of sea-level might be expected to be general and fairly uniform over long distances. The area of the British Isles is too restricted to permit us to believe that there could ever have been any serious difference in sea-level between the eastern and western coasts, or between the northern and southern limits of the country. Whether, therefore, the surface of the sea rose upon the land or sank away from it, we should find the records of these changes to extend over the entire region, and to be marked on the whole by a persistent uniformity of level. But an examination of the evidence fails to furnish proofs of any such extension and uniformity.

In the first place, the raised beaches, although so perfectly developed over nearly the whole of Scotland, disappear towards the north among the Orkney and Shetland Islands where, had they ever existed, they had every chance of being as well preserved as anywhere on the mainland. These islands obviously lay outside of the area affected by the movement that led to the formation of the beaches. But they could not have escaped from the effects of any rise in the level of the sea. Again, it is incredible that if the great 100-foot terrace, so prominent a feature in Scotland, had been formed by an uprise of the surface of the sea, the same terrace should not have been visible in thousands of favourable positions in England, Wales, and Ireland. Its entire absence cannot be accounted for by the presence of former ice-sheets in these regions, or by subsequent denudation. This absence may surely be taken as proof that the terrace never extended over these parts of our islands.

In the second place, had the position of the buried forests in the southern half of England and Wales been due to a rise in the sea-level, similar evidence of submerged land-surfaces at corresponding depths should have been met with generally round our coast-line. Neolithic man was an inhabitant of the country before this submergence was complete, and has dropped his handiwork in the beds of peat. In the north of Ireland and in central Scotland, however, during Neolithic time the land was emerging from the sea, and man has left his flint-flakes and weapons in the youngest raised beaches. Thus in the same period of geological time the sea-level must be supposed to have risen 50 or 60 feet in the south, and to have sunk 25 or 30 feet in the north. But we cannot suppose that within a distance of 300 or 400 miles there could have been a difference of 75 feet or more in the level of the water.

In the third place, there can be little doubt that when accurate levellings are taken of the raised beaches, it will be found that their apparent horizontality is not absolute, but that they rise slowly in certain directions, more particularly towards the axis of the country. It is not improbable also that a difference of level will be detected between the same beach on the eastern and on the western coast, and between its most northerly and most southerly parts. Such evidence of a deformation of the land can only be determined by careful geodetic measurements still to be undertaken.

In the meantime, on a review of the whole evidence, the author felt confident that the balance of proof is largely in favour of the old belief that the changes of level, of which our islands furnish such signal illustrations, have been primarily due, not to any oscillations of the surface of the ocean, but to movements of the terrestrial crust connected with the slow cooling and contraction of our globe. If this belief is to be overthrown, better evidence must be brought against it than has been hitherto adduced.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Oxford.—On Saturday, May 28, the following honorary degrees were conferred on foreign delegates of the International Association of Academies:—D.C.L., Chevalier Edouard Descamps (of the University of Louvain), Ministre d'État, Sénateur Belge. D.Litt., J. L. Heiberg, University of Copenhagen; M. Émile Senart, Académie des Inscriptions et Belles-Lettres, Paris; M. Boutroux, Académie des Sciences Morales et Politiques, Paris; Prof. Collignon, Académie des Inscriptions et Belles-Lettres, Paris. D.Sc., Prof. Dr. Flechsig (Leipzig), Kgl. Sächsische Ges. der Wissenschaften; Prof. E. Ehlers, Kgl. Ges. der Wissenschaften, Göttingen; M. A. Giard, Académie des Sciences, Paris; Dr. Victor von Lang, Kaiserl. Akad. der Wissenschaften, Vienna; Prof. H. Mohn, chairman of the committee of the Videnskabs Selskab, Christiania; and Prof. H. Obersteiner, of the University of Vienna.

A meeting of the Junior Scientific Club was held on May 27. Papers were read by Mr. R. T. Lattey, on "Electrochemical Actinometers," and by Mr. E. C. Atkinson, on "Surveying in South Africa."

The following are among the honorary degrees to be conferred at the Encænia on June 22:—D.C.L., Mr. Charles Booth, F.R.S., president of the Royal Statistical Society. D.Sc., the Hon. C. A. Parsons, F.R.S.; Prof. Pierre Curie; Sir W. S. Church; Sir Andrew Noble, F.R.S.; Sir William Crookes, F.R.S.; Sir David Gill, F.R.S.; Sir John Murray, F.R.S.; Prof. Alfred Marshall; Prof. J. J. Thomson, F.R.S.; Prof. Horace Lamb, F.R.S.; Prof. A. R. Forsyth, F.R.S.; Prof. Dewar, F.R.S.; and Prof. Larmor, Sec.R.S.

Cambridge.—The following are the speeches delivered by the Public Orator, Dr. Sandys, on May 28, in presenting the under-mentioned members of foreign academies for the degree of Doctor in Science, *honoris causâ*:—

Prof. Bakhuyzen, of Leyden.

Inter doctores nostros novos primus hodie progreditur Scientiarum Academiae Amstelodamensis praeses, Batavorum astronomus insignis. Abhinc annos septemdecim consilii magni inter auctores fuit, quo caeli totius stellae, luminis ipsius auxilio chartis impressae, accuratissime redderentur. Etiam altero in opere immenso cum aliis consociatus est, quo caeli parte Boreali in regiones sedecim divisa, stellarum multitudo infinita minutissime observaretur. Iuvat hodie recordari caeli regionem astronomo Leidensi assignatam regioni Cantabrigiensi esse conterminam. Idem latitudinis (ut aiunt) varietatem, orbis terrarum axe leviter vacillante exortam, diligenter exploravit. Talium virorum ope Europae gentes scientiae amore excitatae, etiam in orbe terrarum accuratius dimetiendo invicem certant, astronomi illius antiqui laudem aemulatae,

> "descripsit radio totum qui gentibus orbem."

Prof. Famintsyn, of St. Petersburg.

Russorum ab imperio adest botanicae professor eximius, qui studiorum provinciam nactus pulcherrimam, rerum omnium, quas terra gignit, physiologiam inter primos exploravit. Quam exquisitis usus experimentis, ostendit artificio quam admirabili herbarum genus omne solis radiis tactum virescat; etiam subter aquas algae minutissimae motu tremulo vibrent; foliorum denique omnium in cellis primordia quaedam viriditatis sese explicent, sed eadem solem nimium reformident. Quam feliciter idem novo lumine rem obscuram illustravit, vitamque illam communem, quae inter animalia quaedam minutissima et algarum cellulas intercedit, diei in lucem nuper protraxit.

> "sic unumquicquid paulatim protrahit aetas
> in medium, ratioque in luminis erigit oras."

Edmund Mojsisovics, Edler von Mojsvár, of Vienna.

Vindobonensium ab Academia insigni ad nos advectus est vir de geologia praeclare meritus, qui duodequadraginta per annos palaeontologiae studiis deditus, Ammonis praesertim cornua, rupium in sinu insculpta, aevi prioris indicia (prope dixerim oracula) verissima existimavit. Quid dicam